Multi-Straw Prototype Detector

Tension Measurements

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Straw Chamber

The Straw Chamber is a detector whose wires pass through single straws, connected to a high voltage source. Inside the straw, two incoming wires are joined by a non-conductive glass fiber bead.

Straw Chamber cont'd

- Straw (cathode): Kapton - Al - Kapton (LR) layers; 4 mm diameter
- Wire (anode): Au-coated, 25-μm W wire

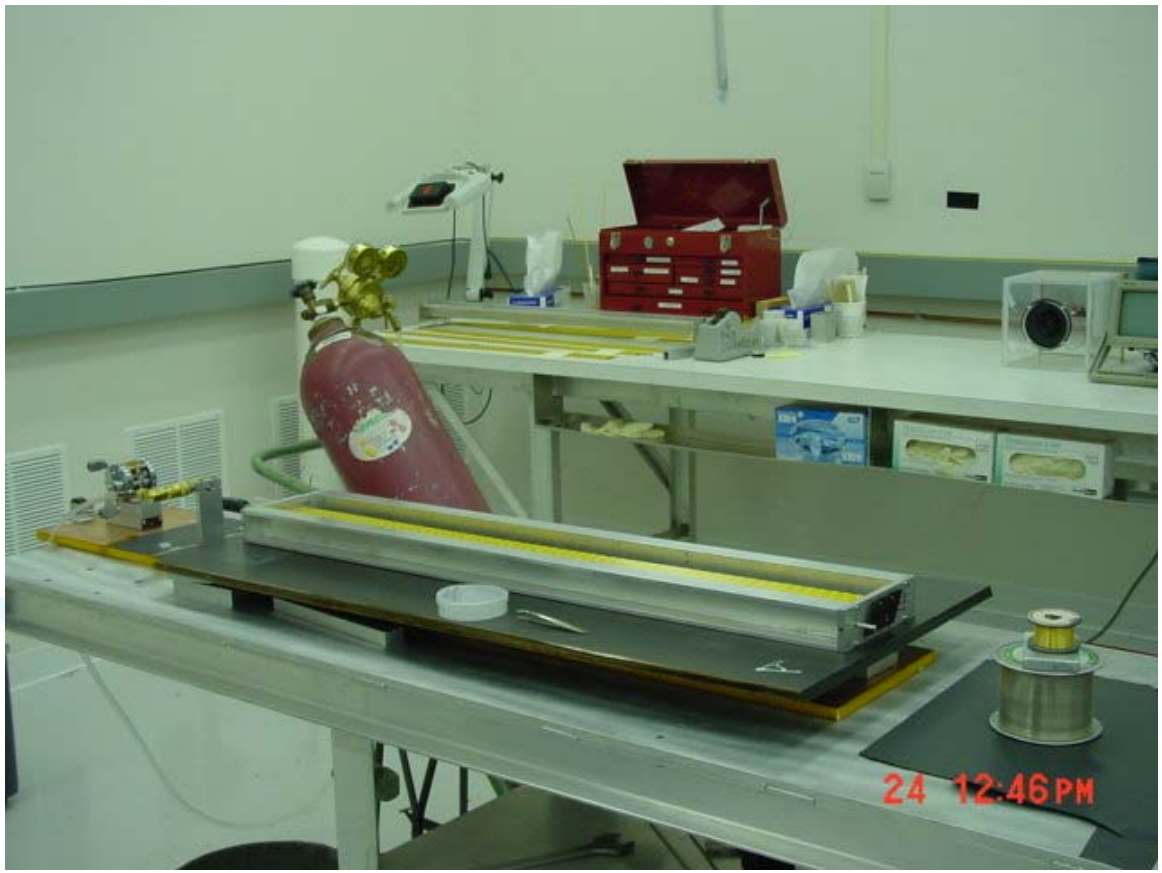
Straw Chamber vs. Wire Chamber

- Straw chamber has been chosen for the BTeV project for one main reason: functionality
  - Broken wires

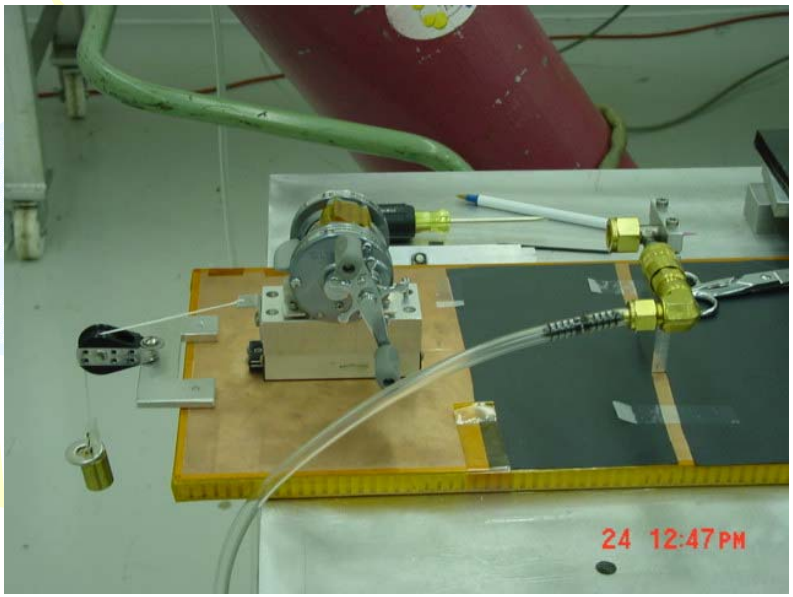
Straw Prototypes

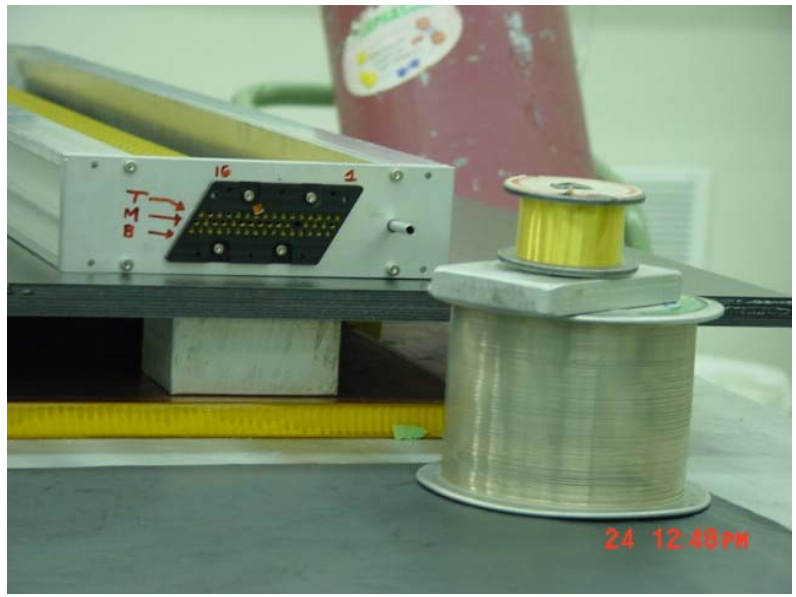
- Two kinds: Single and Multi-Straw
- Certain tension in the wires is required for the detector to operate properly
- Prototypes have a single continuous wire, e.g. no glass fiber bead
- Resonant frequency $\propto$ Tension

How to make a prototype



How to make a prototype cont'd





Theory

- In a vibrational approach, the wire represents a continuous system (many DOF's)
- Due to its characteristics (tensioned and fixed), max amplitude $\propto$ max power occurs at ***harmonic frequencies***
  - ***Wave interference and superposition***
  - ***Nodes and antinodes***

Theory cont'd

Governing equation:

$$f = \frac{n}{2L}\sqrt{\frac{T}{\mu}}$$

n = 1,2,3…

f = harmonic frequency (Hz)

T = tension (N)

n = harmonic (1st, 2nd…)

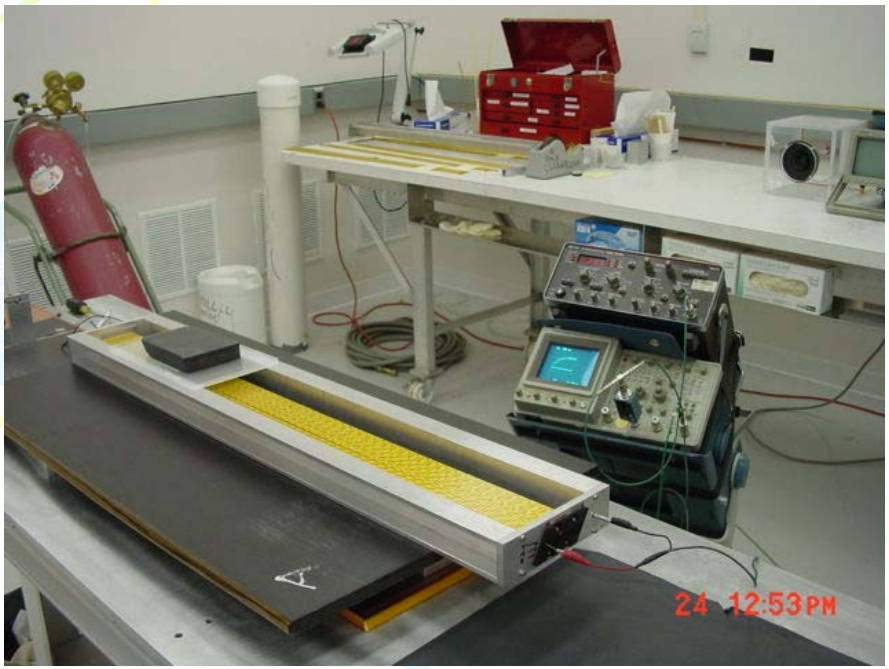
L = length of wire (m)

μ = linear density of wire (kg/m)

Tension tests

- Function Generator (***FG***)
  - An AC current is induced in the wire, located in a magnetic field
  - When the wire is driven to resonance, the effect is perceived in an oscilloscope
  - Current flow induction necessary (***not possible in real detector*** due to wire discontinuity and bead insulation)
- Tone Generator (***TG***)
  - The wire is connected to a constant potential source
  - The straw-wire system resembles a cylindrical coaxial capacitor; Q=CV
  - The wire is vibrated with a loudspeaker, and the power output is read and displayed in a computer (LabVIEW VI) for different frequencies
  - No current needs to be induced; capacitance changes suffice

Tension tests cont'd



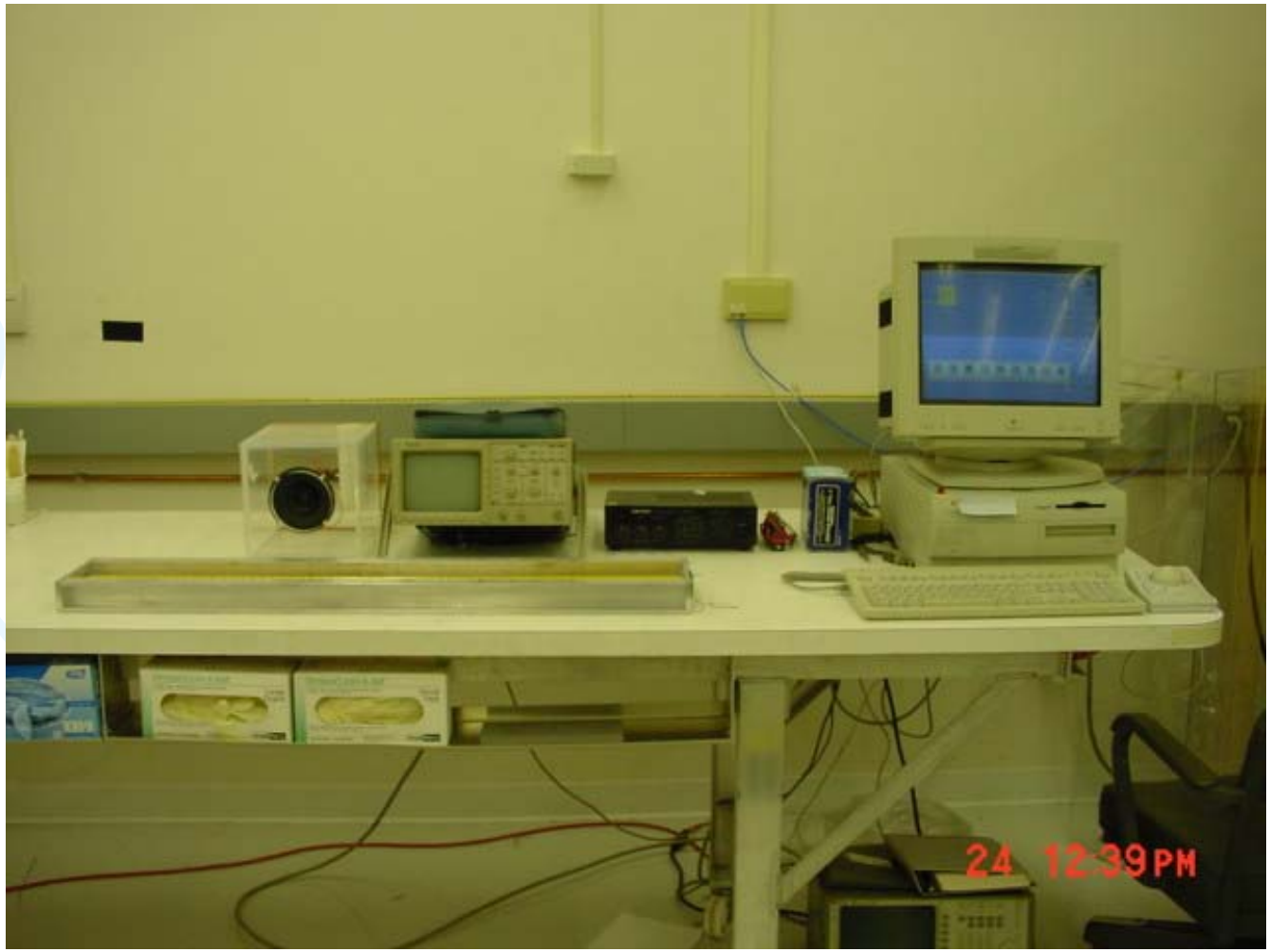
Function Generator (FG)

Tone Generator (TG)

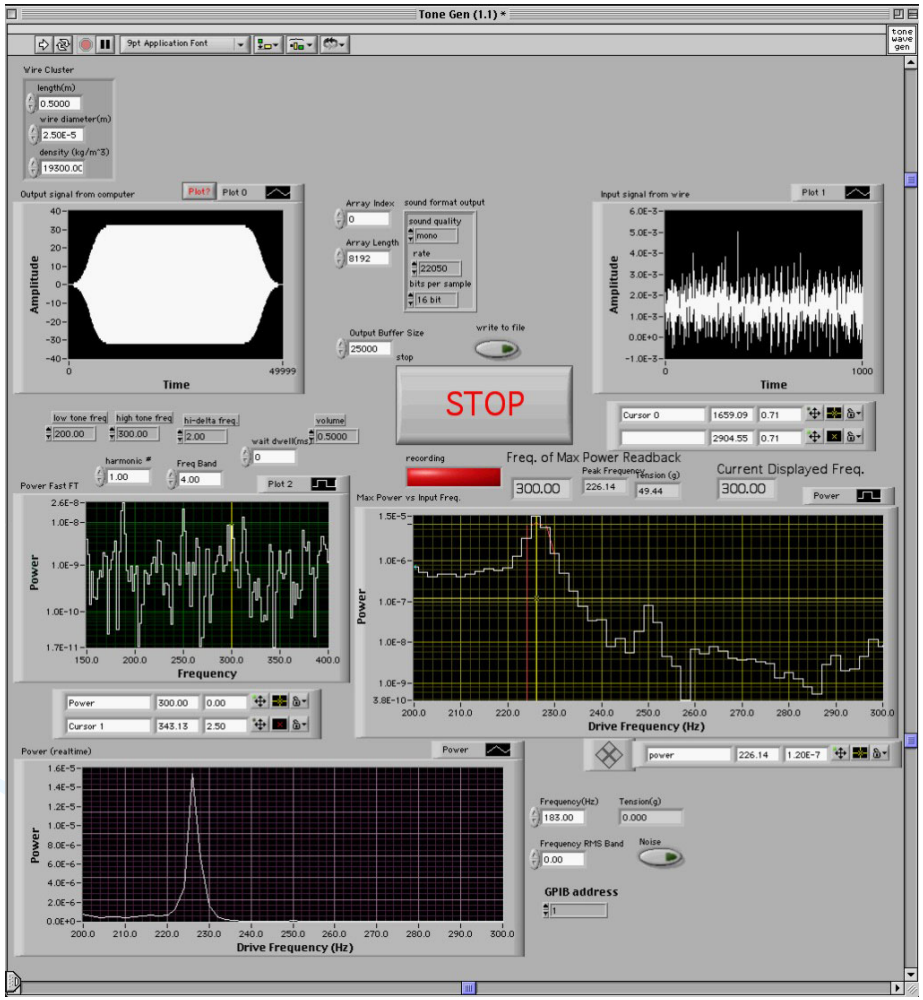
TG Hardware / Software

- Hardware
  - MSP / SSP
  - Voltage source (~81 V)
  - Amplifier
  - Loud Speaker
  - AC signal circuit
  - Oscilloscope
    - Tektronix TDS 350
    - Two channel, 200 MHz, 1 Gs/s
- Software
  - Tone Gen 1.1 (LabVIEW)
    - Generates tone
    - Plots Power as function of frequency
      - Resonance = Max Power

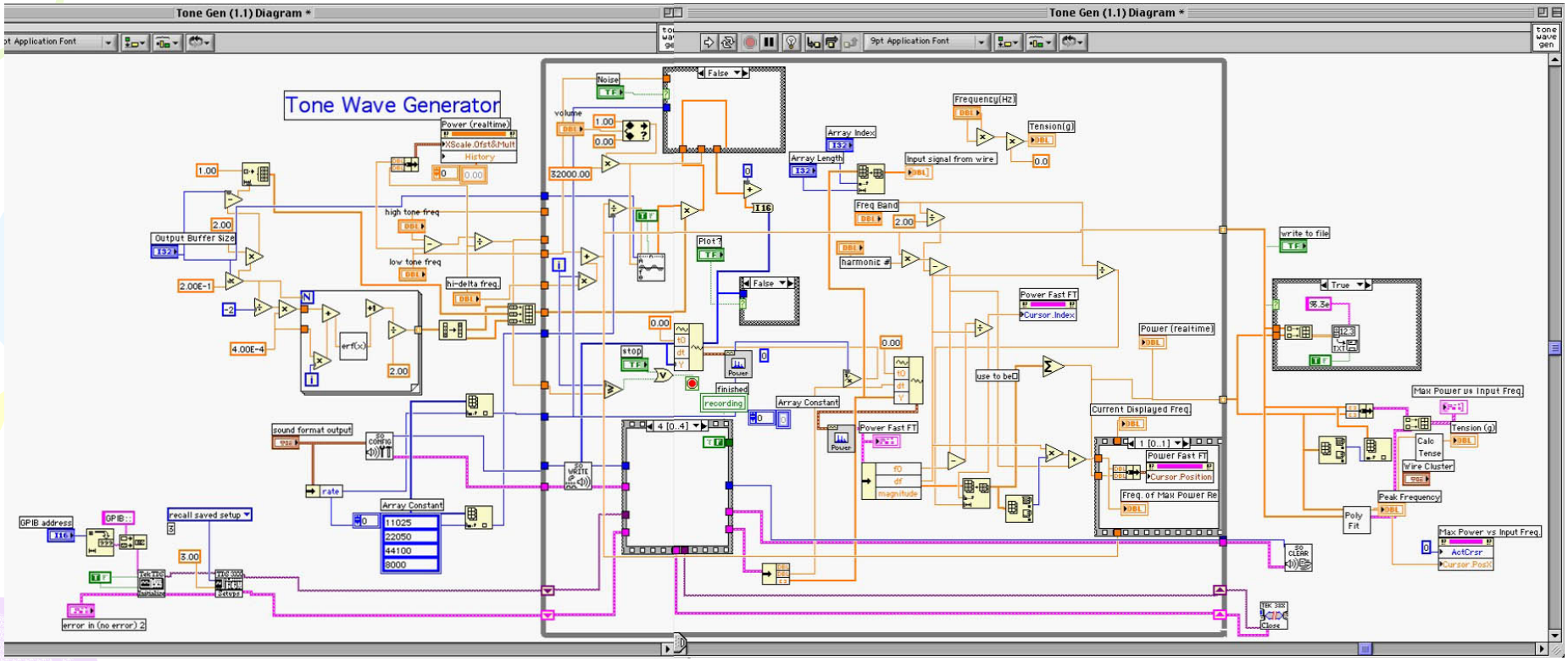
TG Hardware



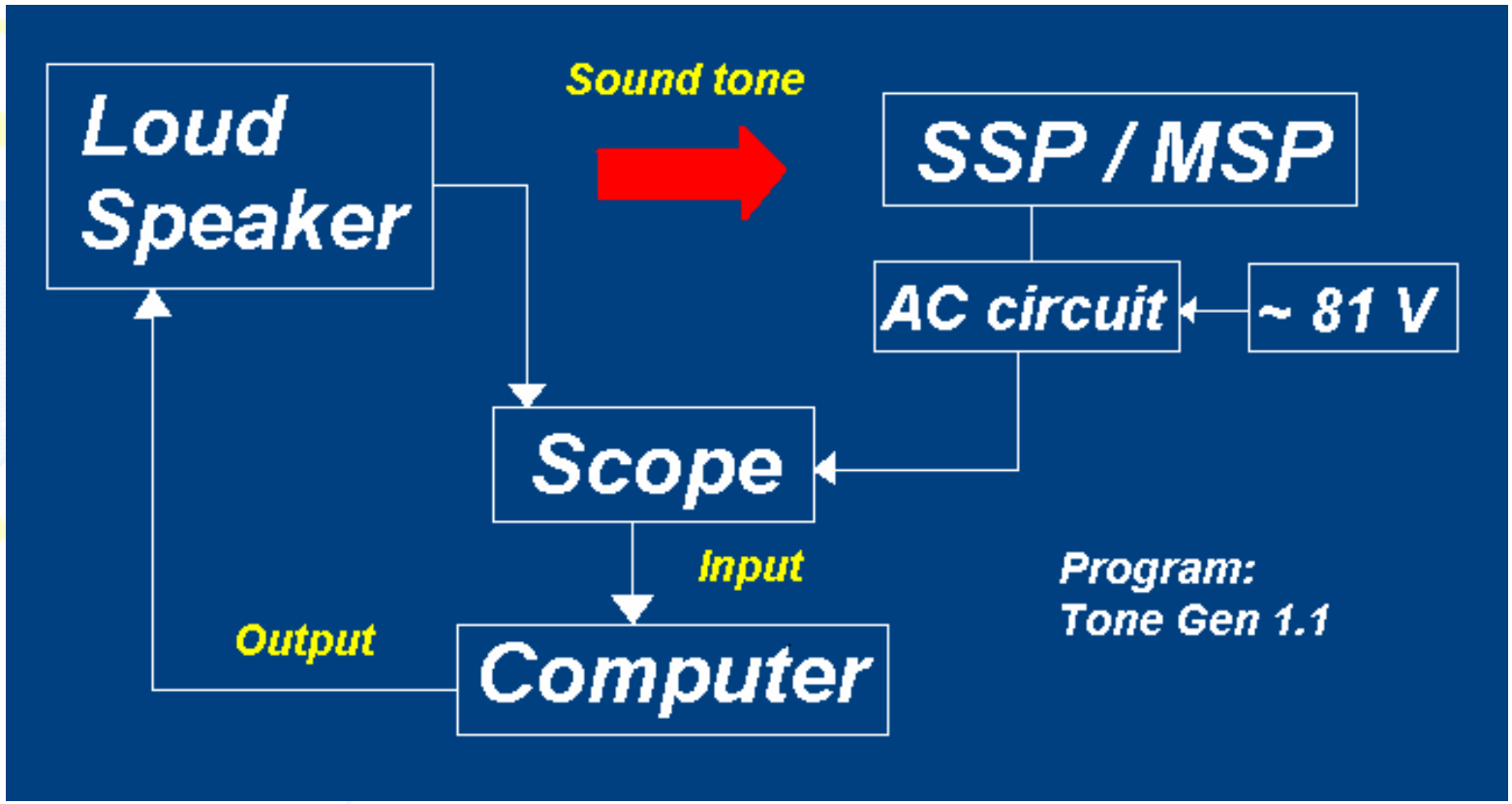
TG Software: VI Panel



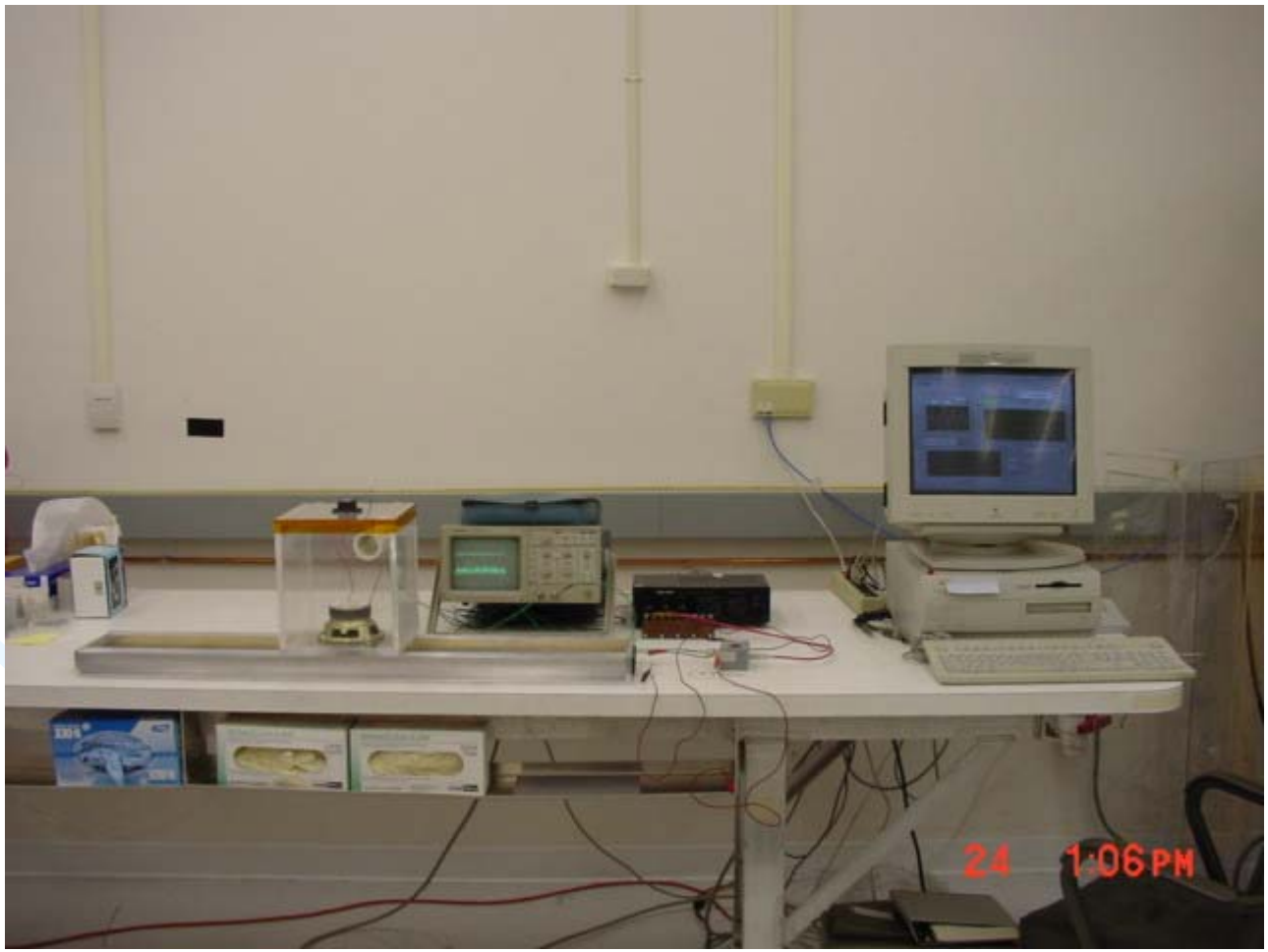
TG Software: VI Diagram



TG Setup


Loud Speaker
Sound tone
SSP / MSP
AC circuit
~ 81 V
Scope
Input
Output
Computer
Program:
Tone Gen 1.1

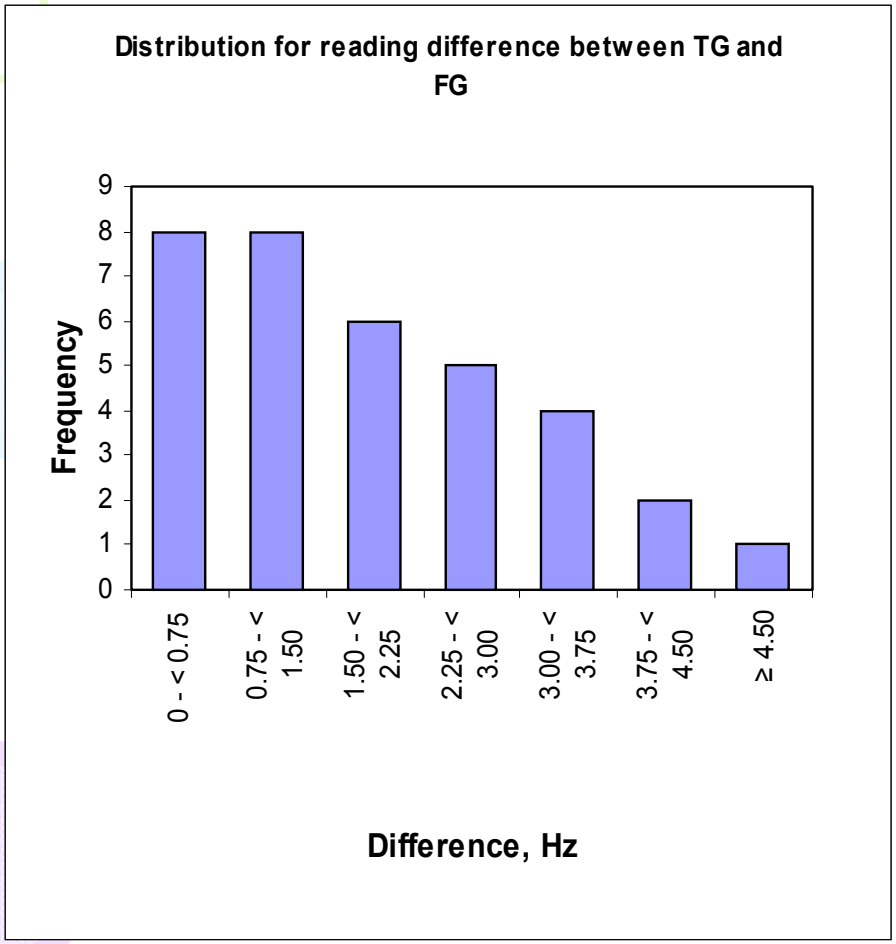
TG Setup cont'd



Experiments

- TG vs. FG
  - Evaluate the difference between FG and TG readings
  - 34 samples
  - MSP used for such purpose
  - ***Different tensions mean different frequencies***
- TG accuracy
  - Evaluate how consistent and accurate is TG
  - 20 samples
  - SSP used in the study
  - ***Expected frequency known (approx. 250 Hz)***

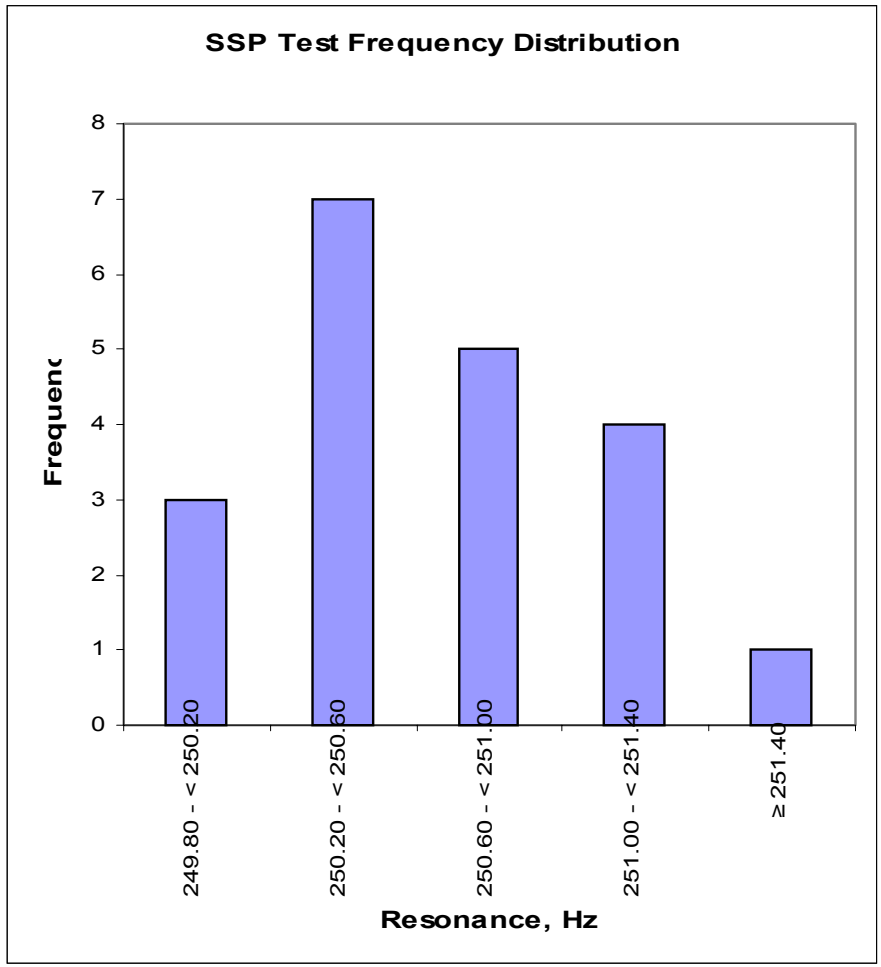
Results: TG vs. FG



- Mean = 1.80 Hz
- Std. Dev. = 1.23
- Graph tends slightly more to a small difference, as shown
- Good news: both of them can be trusted in prototypes *if they are right*
- ***Fact: only TG can be used in real detectors!!***

Results: TG accuracy

- Mean = 250.66 Hz
- Expected ≈ 250 Hz
- Std. Dev. = 0.42
- ***Good news: TG is working right!!***
  - ***TG is potentially useful for real detector***



Conclusion

- TG is a trustworthy device for wire tension measurement, that can be used in the detector and prototypes
- The process has been speeded up, but must be faster if possible for real detector (80,000+ wires)